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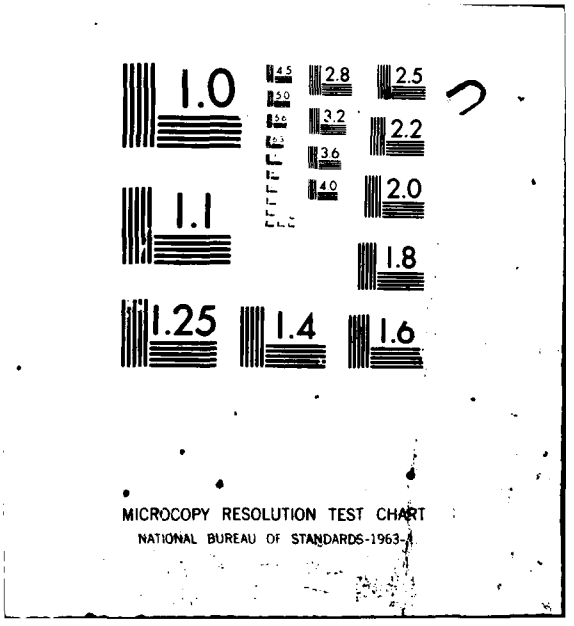
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APPLICATION OF FLIGHT SIMULATOR RECORD/PLAYBACK FEATURE

LEVEL II

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FLYING TRAINING DIVISION
Williams Air Force Base, Arizona 85224

December 1979
Interim Report for Period January 1979 – May 1979

AIR FORCE SYSTEMS COMMAND
BROOKS AIR FORCE BASE, TEXAS 78235

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This interim report was submitted by Flying Training Division, Air Force Human Resources Laboratory, Williams Air Force Base, Arizona 85224, under project 1123, with HQ Air Force Human Resources Laboratory, Brooks Air Force Base, Texas 78235. Dr. Ronald G. Hughes (FTR) was the Principal Investigator for the Laboratory.

This report has been reviewed by the Information Office (OI) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Undergraduate Pilot Training (UPT) students acquired a complex visual flying task in ASPT under one of three instructional conditions which differed in their use of an automated record/playback feature. The study evaluated differences in performance resulting from (a) periodic, repeated use of a recorded, instructor-presented demonstration, (b) periodic use of a replay of student performance, and (c) use of equivalent training time for additional practice.

The data indicated little or no instructional value associated with repeated exposures to the original demonstration of the task to be learned. While the 'replay' condition produced terminal performances with fewer errors on the average than the 'demo' condition, differences between 'practice' and 'replay' groups were not

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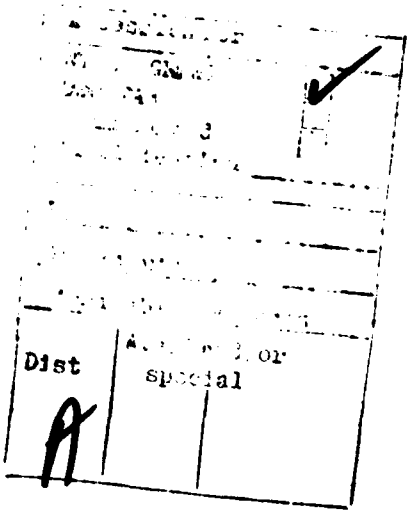
statistically significant. The surprising finding of the study was the effectiveness of simple practice relative to that of the two, so-called, "instructional" conditions. These data would suggest that, at least in some instances, a training approach that provided only for basic performance feedback (e.g., a "score") might be equally as effective as one with provision for presenting repeated access to recorded demonstrations and/or replays of previous performance.

PREFACE

This effort was conducted by the Flying Training Division of the Air Force Human Resources Laboratory, Williams Air Force Base, Arizona. The project was completed under Work Unit 11230234 entitled Advanced Instructional Features and Methods in ASPT. The work unit supports project 1123, Flying Training Development; task 112302, Instructional Innovations in Flying Training. These efforts further support AFHRL Planning Objective G03, Specific Goal 2, Training Methods and Media.

Special thanks are extended to Mr. James F. Smith for his helpful comments in the preparation of this report.



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APPLICATION OF FLIGHT SIMULATOR RECORD/PLAYBACK FEATURE

I. INTRODUCTION

Most flight simulators now in use incorporate training features that are intended to promote greater instructional efficiencies (Caro, 1979; Hughes, 1979; Isley & Miller, 1976). One such training feature is referred to generically as "record/playback." This feature permits the simulator to reproduce a previously established segment or phase of flight without direct intervention by the trainee or the Instructor/Operator. These events include motion system, primary flight controls and displays, and appropriate sensor displays. Alternative applications of the record/playback feature include employing it either for the purpose of presenting a recorded demonstration or for replaying student performance for the purpose of critique.

Although interest has been expressed in capitalizing upon such unique training capabilities (USAF, 1978), the evidence suggests that simulators continue to be used as "substitute" aircraft. Limitations inherent in the use of operational equipment as training devices continue to be imposed upon simulator based training. The record/playback feature, for instance, continues to be used only in the most rudimentary fashion to provide a duplicate of the live demonstration as provided in the actual operational equipment. Rarely is the use of record/playback incorporated with other features (for example, freeze and in-flight condition store) to achieve a unique instructional capability.

Despite the literature on the educational use of video-taping for providing instructional feedback (Baron, 1969; Carre, 1973; Kraft, 1973; Pease & Damron, 1974; Sanders, 1969), unequivocal evidence still does not exist upon which to base a rationale for the instructional use of an automated record/playback feature in flying training simulation. Since the use of demonstrations and performance replays both constitute instructional events which subtract from the time available for student practice, it is imperative that their content and placement in the learning sequence be optimized. In automated approaches to flying training simulation, for example, where interaction with a live instructor may be absent and where interaction in terms of feedback characteristics of the device may be limited, the use of these features becomes even more critical.

The present study created a training setting where instructional material was presented primarily through pre-recorded material and where feedback was limited to an overall performance "score." Instructional conditions were arranged so as to address the following questions:

1. For the particular task selected for study, does periodic use of performance playback result in more rapid acquisition than use of the equivalent amount of time for additional student practice?

2. For the particular task selected for study, do subsequent exposures to the original demonstration result in more rapid acquisition than use of an equivalent amount of time for additional student practice?

II. METHOD

Subjects. Fifteen USAF Undergraduate Pilot Training (UPT) students assigned to Williams AFB, Arizona, served as subjects. All students serving as subjects were still at a "pre-aerobatic" phase in the T-37 portion of the UPT syllabus. No subjects had previous experience with any aerobatic maneuver or with any of the major component parts of the cloverleaf maneuver flown in the present study.

Apparatus. The study was conducted on the Advanced Simulator for Pilot Training (ASPT) located at the Flying Training Division of the Air Force Human Resources Laboratory, Williams AFB. Technical references for the device are found in Gum, Albery, and Basinger (1975) and in Rust (1975). Provisions for force cueing (e.g., platform motion, G-seat, and G-suit) were not used. A computer-generated visual scene of the Williams AFB training environment was presented via ASPT's seven 36-inch monochromatic cathode-ray tubes placed around the cockpit giving the pilot +110 degrees to –40 degrees vertical cueing

and ±150 degrees of horizontal cueing. The aerodynamic models driving the simulator were those of the T-37 aircraft.

Procedure

Preflight Briefing. Following a videotaped introduction to the purpose of the study which included a 5 minute preflight briefing on performance of the cloverleaf maneuver, each student entered the simulator and witnessed a recorded demonstration of the task to be learned, i.e., the first two leaves of a cloverleaf maneuver (see Figure 1). The demonstration included all visual cues associated with performance of the task as well as all instrument readings and stick and throttle positions. The simulation also included recorded aural narration.

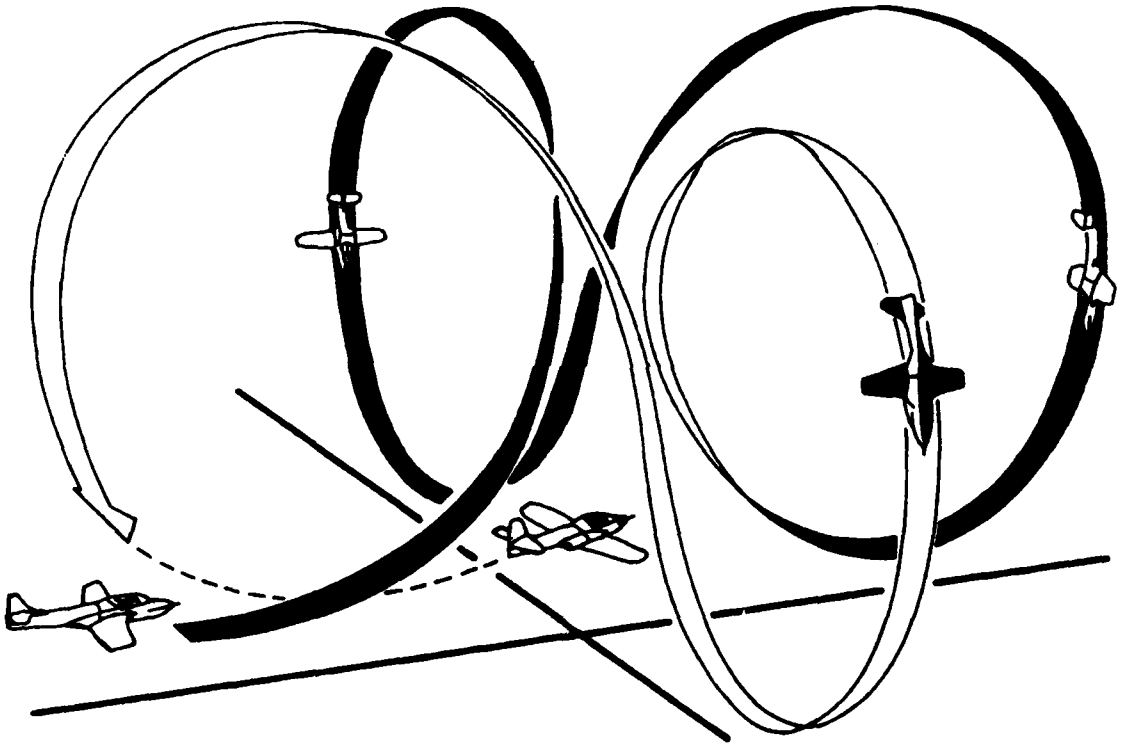


Figure 1. **Flight path of experimental maneuver (darkened area).**

Instructional Conditions. The condition under which a student practiced the task was determined by assignment of the student to one of three instructional groups (see below). Regardless of group assignment, all students, following the initial demonstration, performed two leaves of a cloverlead maneuver for four blocks of three practice trials each (i.e., each student practiced 12 complete repetitions of the task). The three instructional conditions are described below. Five students were assigned to each of the three different instructional conditions:

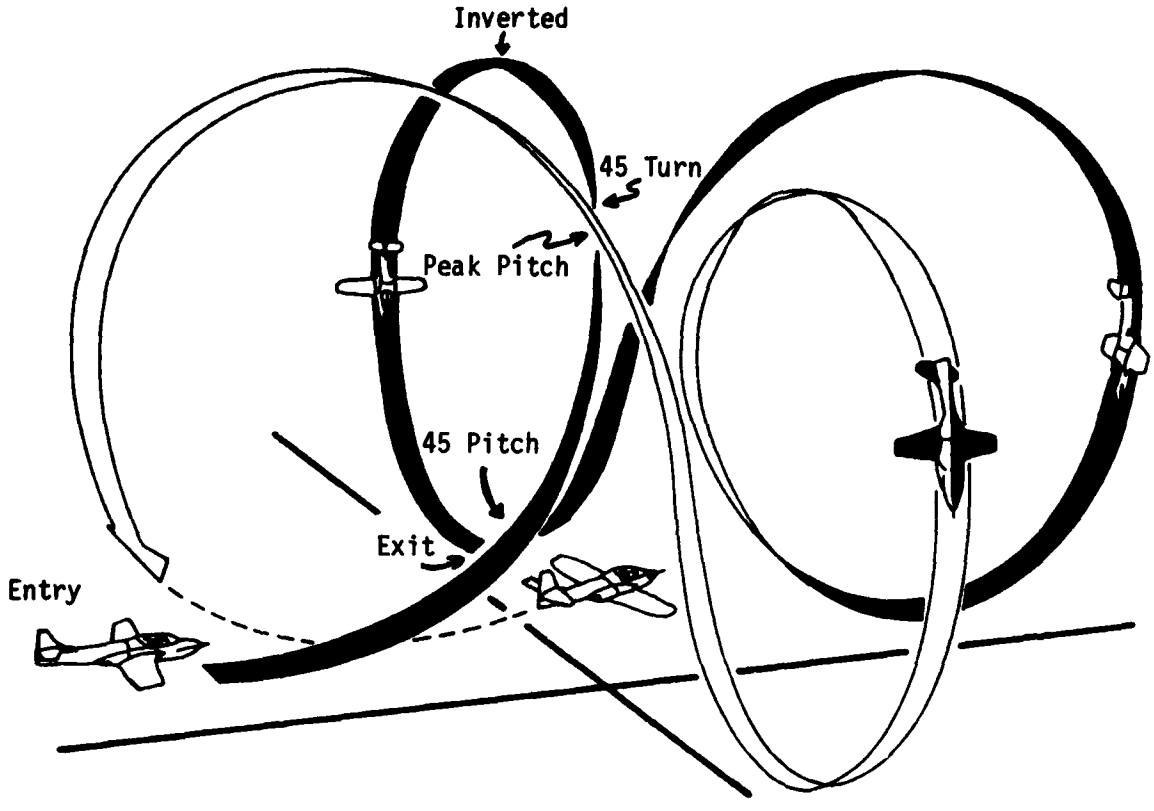
1. *"Demo" Condition.* Between each successive block of trials, students in the Demo condition witnessed the original, full demonstration of the cloverleaf maneuver with recorded instructor pilot voice instruction.

2. *"Replay" Condition.* Between each successive block of trials, students in the Replay condition witnessed a replay of the immediately preceding trial. During the performance replay, narration was provided by an instructor seated in a second cockpit "slaved" to that of the student's.

3. *"Practice" Condition.* Between each successive block of trials, students in the Practice group used the available time to perform an additional practice trial.

Scoring and Performance Measurement. Other than the performance feedback contained in the instructor's narration accompanying the replay in the Replay condition, the only feedback provided to the student pilot was an overall performance rating (Unsatisfactory, Fair, Good, Excellent) given by an instructor located in a second simulator cockpit "slaved" to the student's cockpit. The instructor's cockpit provided all instrument readings and visual cues available to the student. Scoring criteria used by instructor pilots were those set forth in Air Training Command Manual 51-4, "Primary Flying Jet." Parameters sampled by the system's automated performance measurement capability are shown in Figure 2. Also presented in Figure 2 are the tolerance bands for each measure used to define acceptable performance. Scores derived from the automated performance measures consisted of the number of out-of-tolerance measures for each of the two leaves of the maneuver. The scoring profile is described in Appendix A. Since no prior studies were available to serve as guidance in the derivation of a performance score from those parameters sampled by the system's automated performance measurement capability, two methods for generating scores were employed.

In the first method, all parameters shown in Figure 2 with the exception of those for Entry (predetermined by an initial condition) and those for Entry into the second leaf (redundant with the Exit value obtained on the first leaf) were used as a basis for a score. In the description of the results which follows, the error score derived in this manner is referred to as having come from the "Original Criteria." In the second method, only those parameters indicated in Figure 2 by an asterisk served as a basis for a score. A score derived in this manner will be referred to later as having come from the "Modified Criteria." Parameters selected for inclusion in the modified criteria were those judged by AFHRL/FT instructor pilots as being predictive of overall performance.



Scoring Points for Each Leaf	Parameter Scored	Tolerance Band
Entry	1. Airspeed (KIAS)	215–230
	2. Heading (Deg)	Actual Value
45° Pitch	1. Pitch (Deg)*	40–50
	2. Airspeed (KIAS)	160–200
	3. Average GS*	2.5–3.5
Peak Pitch	1. Pitch (Deg)	60–70
45° Turn	1. Pitch (Deg)*	60–70
	2. Airspeed (KIAS)	140–160
	3. Bank (Deg)	85–95
	4. Average Gs	1.5–2.5
Inverted	1. Heading Change (Deg)*	80–100
	2. Bank (Deg)*	170–190
	3. Airspeed (KIAS)	100–120
	4. Average Gs	0.5–1.3
	5. Average Roll (Deg)	minus 15 – minus 21
Exit Value	1. Airspeed (KIAS)*	190–230
	2. Heading Change (Deg)*	80–100
	3. Average Gs	2.0–3.0

Figure 2. **Automated performance measurement.**

III. RESULTS

Subjective Performance Ratings. On the average, the subjective performance ratings given by instructor pilots for each of the four blocks of trials for each of the three experimental groups reflected little change in student performance across blocks of trials regardless of the conditions under which the task was acquired. Unsatisfactory performances at the outset of training improved, on the average, only from the Unsatisfactory to the Fair to Good range.

It is not critical for the present study that instructor ratings appear to have been insensitive to changes in student performance. It is important to point out here that the cloverleaf maneuver was introduced to students at a pre-aerobatic stage of training. These students had none of the prerequisite flying skills possessed by students acquiring the maneuver at the normal point in the syllabus. Choice of the experimental task was based upon (a) the point in UPT syllabus at which students were available, (b) the capability for automated performance measurement, and (c) the extent to which the task was representative of other complex flying maneuvers. Performance should therefore be viewed as performance on a complex psychomotor task representative of those acquired in aerobatic maneuvers. It would be inappropriate to interpret the results which follow in terms of their direct application to the specific operational training of the cloverleaf maneuver in UPT.

Automated Performance Scores. Scores based upon "Original" and "Modified" criteria are presented in Table 1 for each experimental group across blocks B1 to B4. While the correlation between error scores defined in these two ways was found to be statistically significant ($r = .50, p < .05$), the magnitude of the relationship argues against their direct interchangeability.

Table 1. **Automated Performance Scores**

		B1	B2	B3	B4
Modified Criteria					
Demo	$\bar{X}$	29.20	27.80	23.80	24.00
	s.d.	3.19	1.30	6.38	6.63
Replay	$\bar{X}$	21.80	18.20	14.20	14.80
	s.d.	9.20	4.87	1.64	6.57
Practice	$\bar{X}$	25.60	21.60	19.80	18.20
	s.d.	4.67	4.39	3.49	4.27
Original Criteria					
Demo	$\bar{X}$	22.80	21.46	18.20	18.00
	s.d.	3.65	3.98	6.46	4.68
Replay	$\bar{X}$	16.60	15.13	10.87	10.80
	s.d.	5.26	1.61	3.48	6.70
Practice	$\bar{X}$	19.33	16.20	14.73	14.87
	s.d.	4.38	4.80	5.45	3.76

Block 1 performances were compared across the three experimental groups for each of the two methods used in defining errors to determine whether significant differences in group performance existed at the outset of training. (Note that all three experimental groups performed under the same training conditions during Block 1.) Regardless of whether "Original" or "Modified" criteria served as the basis for the error score, differences between groups on Block 1 did not exceed differences that would have been expected on the basis of chance. Since the performances of all groups could be considered comparable at the outset of training, the data in Figure 3 have been presented in terms of "Performance (Errors) Relative to Block 1." Performance is displayed on the vertical axis; blocks of trials are displayed on the horizontal axis. Differences between subjects due to group assignment as well as differences in performance over trials were analyzed separately for each method used to define errors (i.e., original vs. modified criteria). Data were analyzed by a split plot factorial design. Differences between subjects due to assignment to

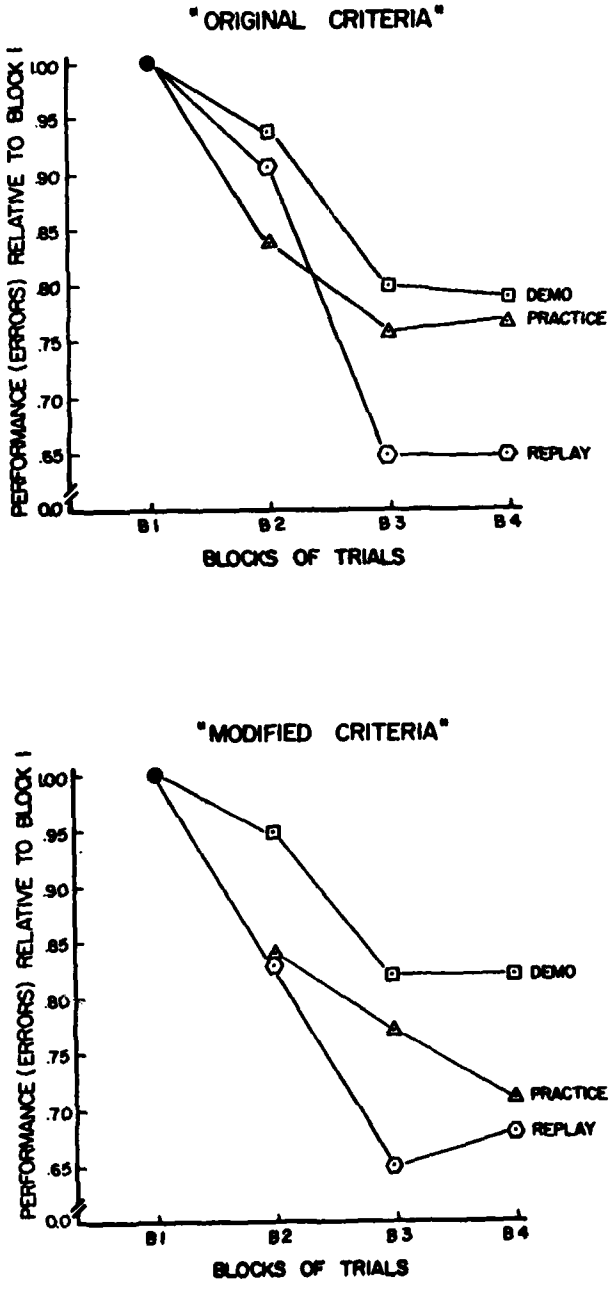


Figure 3. **Performances across successive blocks of trials.**

experimental condition (Group Effect) were significant for both the "Modified" Group ($F(2,12)=9.2623$, $p < .05$) and the "Original" Group ($F(2,12)=3.8230$, $p < .05$). Significant improvement over trials (Trials Effect) was also noted for the "Original" Group ($F(2,24)=4.3702$, $p < .05$) and the "Modified" Group ($F(2,24)=3.6191$, $p < .05$). There were no significant group by trial interactions noted. Summary tables for the analyses are presented in Appendix B.

As is clear from Figure 3, differences between the three approaches used to teach the task are difficult to distinguish early in training. One-way ANOVAs indicated that differences which had begun to emerge by Block 3 and Block 4 favored (at the $p = .05$ and $p = .06$ level for the "Modified" and "Original" criteria, respectively) the Replay condition over the Demo condition. The relationship of performances in the Practice group relative to those of the Demo and Replay groups was less clear.

It is important to point out that when performance of the Practice group was considered as a "baseline" against which to evaluate the effectiveness of the Replay condition, no significant differences in performance were noted. Caution must be taken in the interpretation of the present findings both because of the small sample sizes involved and because of the type of task and experience level of subjects at the time the particular task was introduced. It is important also to note that although Block 1 differences between groups were not statistically significant, differences between the performances of each of the three groups throughout training were very close to differences between groups at the outset of training. While normalizing performances relative to Block 1 was felt to be justified for the purpose of comparing improvements in performance across groups, interpretation of the data when transformed in this way must remain guarded.

Results

The results of this study indicated the following:

1. There were significant differences between subjects during the acquisition of the task, as a function of the instructional condition to which they were assigned.

2. Regardless of the instructional condition to which subjects were assigned, performances showed significant improvement as a function of continued practice on the task.

3. By the end of training (i.e., by the end of Block 4), there was a trend toward best performance in the Replay condition and poorest performance in the Demo condition.

4. Performances in the Practice and Replay groups did not differ significantly at the end of training.

IV. CONCLUSION

Within the context of the present study, there appears to have been little instructional value associated with repeated exposure to the original demonstration. While the Replay condition produced terminal performances with fewer errors on the average than the Demo condition, it must be pointed out that the difference between the Practice and Replay groups at the termination of training was not statistically significant. The most surprising aspect of the present data was the performance of students in the Practice group relative to that of students in the so-called "instructional" conditions. These data suggest that, at least in some instances, a training approach (or device) that provides only for basic performance feedback (e.g., a "score") might be equally as effective as one with provision for presenting repeated access to recorded demonstrations and/or replays of previous performance. In terms of the experimental designs used to evaluate the effectiveness of automated training features such as record/playback, the present design emphasizes the desirability of a no-instruction (practice only) control group as a baseline against which to evaluate the effectiveness of the feature in question.

The training implications of this study are as follows:

1. Repeated presentations of a recorded demonstration used to introduce a student to a new task appears to have little instructional value. The training time consumed by repeating the demonstration would appear to be better used for providing the student with additional time to practice the task for feedback in the form of replays.

2. It is not possible to state unequivocally that use of the playback feature leads to more rapid acquisition of a task in the simulator.

3. Complex visual flying tasks such as the cloverleaf may be acquired in the simulator with a minimum of instructor feedback. The implication is that many flying tasks may lend themselves to partial or full automation in the simulator because of the self-generated feedback in flying.

4. According to Caro (1979), the extent to which students are able to successfully acquire performances in the absence of a highly structured training environment may be related to individual differences (e.g., field independence-field dependence). Such variables should be investigated as simulator training becomes more and more automated.

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APPENDIX A: SCORING PROFILE: CLOVERLEAF

SDS Guide

Sds Key	Data Pool Label	Description
Entry VL1	ASCORE 31	Entry airspeed
	ASCORE 32	Entry heading
45 Pitch 1	ASCORE 33	G loading
	ASCORE 34	Airspeed
PK Pitch 1	ASCORE 35	Peak pitch
45 Turn 1	ASCORE 36	Pitch at 45-deg turn
	ASCORE 37	Airspeed 45-deg turn
	ASCORE 38	Bank 45-deg turn
	ASCORE 39	Gs 45-deg turn
Invert 1	ASCORE 40	Heading inverted
	ASCORE 41	Bank inverted
	ASCORE 42	Airspeed
	ASCORE 43	Gs inverted
A/M GS 1	ASCORE 46	Ave Gs entry to 45 pitch
	ASCORE 47	Max Gs entry to 45 pitch
	ASCORE 48	Ave Gs 45 pitch to 45 turn
	ASCORE 49	Max Gs 45 pitch to 45 turn
	ASCORE 50	Ave Gs 45 turn to inverted
	ASCORE 51	Max Gs 45 turn to inverted
	ASCORE 52	Ave Gs inverted to level
	ASCORE 53	Max Gs inverted to level
AV RL/G1	ASCORE 44	Ave Roll rate
	ASCORE 45	Ave rolling Gs
Exit VL 1	ASCORE 54	Exit airspeed
	ASCORE 55	Exit heading
Roll Dir 1	EDGSCR 1	True = left rolls False = right roll – error
Smooth 1	ASCORE 01-20	Smoothness (SP #2)

Scoring Profile

Eight second delay until command "CLEAR TO START."
Smoothness starts scoring after command.
Airspeed and heading captured when pitch greater than 10 degrees.
Gs and airspeed captured at 45-degree pitch.
Peak pitch is captured during roll to inverted.
Pitch, airspeed, Gs, and bank captured at 45 degrees of turn.
Heading, bank, airspeed and Gs are captured when pitch less than zero.
Exit airspeed and heading are captured when pitch greater than zero and smoothness stops scoring.
Max Gs and average Gs are collected for the segments: Entry to 45-degree pitch; 45-degree pitch to 45-degree turn; 45-degree turn to inverted and inverted to level flight.
Average roll rate and roll Gs are collected during the segment 45-degree pitch to inverted.
The above scoring profile is performed for each leaf.
Scoring is selectable to score two or four leaves.

APPENDIX B: ANALYSIS OF VARIANCE SUMMARY TABLES

ANOVA

Source	df	SS	MS	F-Value	P-Value
		Errors ("Original" Criteria)			
Group	2	365.1130	182.5565	3.8230	.0511
Between	12	573.0236	47.7520		
Treatment	2	91.3797	45.6898	4.3702	.0235
GxT	4	14.6962	3.6741	.3514	.8411
Within	24	250.9160	10.4548		
		Errors ("Modified" Criteria)			
Group	2	675.3333	337.8667	9.2623	.004
Between	12	437.7333	36.4778		
Treatment	2	116.1334	58.0667	3.6191	.0412
GxT	4	10.1333	2.5333	.1579	.9511
Within	24	385.0665	16.0444		